A New and Endangered Species of *Hyperacanthus* (Rubiaceae) from Madagascar: *H. mandenensis*

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ABSTRACT. *Hyperacanthus mandenensis* Rakotonasolo & A. P. Davis is described as a new species on the basis of its large corolla (10.5–16.5 cm long), included style, and thick fibrous fruit wall (6–10 mm thick). No other species of *Hyperacanthus* E. Meyer ex Bridson possess these characters: *H. ambovombensis* Rakotonasolo & A. P. Davis, *H. amoenus* (Sims) Bridson, *H. grevei* Rakotonasolo & A. P. Davis, and *H. microphyllus* (K. Schumann) Bridson all have small corolla tubes (less than 5 cm long), a style that is positioned more or less level with the corolla throat, and a thin non-fibrous fruit wall (less than 3 mm thick). *Hyperacanthus mandenensis* is restricted to the forests of Petriky, Mandena, and St. Luce, in an area corresponding to a proposed mining site, in southeastern Madagascar (Toliara Province). Using the IUCN Red List Category criteria, *H. mandenensis* is currently assessed as Endangered, although without appropriate conservation measures this species would easily become Critically Endangered, or even Extinct.

Key words: conservation, Gardenieae–Gardeniinae, *Hyperacanthus*, ilmenite, IUCN Red List Categories, Madagascar, mining and conservation, Rubiaceae.

The genus *Hyperacanthus* is a member of the tribe Gardenieae DC. subtribe Gardeniinae DC., with a geographical range covering southeastern tropical Africa and Madagascar. It currently comprises four species, two from Madagascar (*H. ambovombensis* and *H. grevei*; Rakotonasolo & Davis, 2001, 2002) and two from Africa (*H. amoenus* and *H. microphyllus*; Bridson & Robbrecht, 1985). It has been estimated (Davis & Bridson, 2003; Davis & Rakotonasolo, 2003) that there are about 30 species of *Hyperacanthus* in Madagascar, although more recent investigations by the first author (as part of an in-depth study of the genus, F. Rakotonasolo, unpublished data 2004) indicate that are about 50 species in Madagascar. The salient characteristics of the genus are: stipules caducous, tightly rolled and often slightly twisted; leaves lacking domatia; inflorescences terminal but often appearing axillary (overtopped) due to shoot extension; paired bracteoles at the base of the calyx and fruit; corolla lobes overlapping to the right in bud; ovary 2- or 4-locular with axile placentation, sometimes with additional basal septa (with parietal placentation); anthers more or less sessile or with very short filaments (ca. 0.1 mm long); and calyx persistent and obvious in fruit. In the past, *Hyperacanthus* has been confused with *Genipa* L., *Gardenia* J. Ellis, and particularly *Rothmannia* Thunberg, but in reality these four genera are clearly very different (Rakotonasolo & Davis, 2002).

A third species of *Hyperacanthus* for Madagascar is described here: *H. mandenensis* Rakotonasolo & A. P. Davis. The description of this species has been prompted by the realization that it could be in danger of extinction due to the likely onset of mining and associated activities in the Taolagnaro (Fort Dauphin) region of southeastern Madagascar.

Hyperacanthus mandenensis is easily separated from the other four described species of *Hyperacanthus* on the basis of its large corolla (10.5–16.5 cm long), included style, and thick fibrous fruit wall (0.6–1 cm thick). *Hyperacanthus ambovombensis*, *H. amoenus*, *H. grevei*, and *H. microphyllus* all have small corolla tubes (less than 5 cm long), a style that is positioned more or less level with the corolla throat, and a thin non-fibrous fruit wall (less than 3 mm thick). *Hyperacanthus mandenensis* also has a larger fruit than the other *Hyperacanthus* species: 2.6–3.7 cm diam. as opposed to less than 2 cm diam. In addition, *Hyperacanthus mandenensis* can be separated from *H. amoenus*, *H. microphyllus*, and *H. ambovombensis* because it has a 4-locular ovary, a characteristic it shares with *H. grevei*. *Hy-*

peracanthus amoenus and *H. microphyllus* have a 2-locular ovary with two additional parietal attachments in the basal half of the ovary (Bridson & Robbrecht, 1985), the ovary thus being 4-locular at the base (Rakotonasolo & Davis, 2002); *H. ambovombensis* has a 2-locular ovary.

Materials and Methods

Herbarium material of this species was consulted at the Royal Botanic Gardens, Kew (K), the Muséum National d'Histoire Naturelle, Paris (P), Recherches Forestières et Piscicoles, Antananarivo (TEF), and Département de Botanique, Parc de Tsimbazaza, Antananarivo (TAN). Field studies were undertaken by us in 2001, and by F. Rakotonasolo in 2002. The measurements and other details given in the description are based on herbarium specimens, material preserved in spirit, and field study.

The conservation status of each species was assessed by calculating the extent of occurrence and area of occupancy using a GIS (J. Moat, pers. comm.) and applying the IUCN Red List Category criteria (IUCN, 2001). The distribution data was analyzed using the methodology and software developed by Willis et al. (2003). Supporting information was provided from field studies.

Description of *Hyperacanthus mandenensis*

Hyperacanthus mandenensis Rakotonasolo & A. P. Davis, sp. nov. TYPE: Madagascar. Toliara: Taolagnaro Prefecture, Mandena Forest, forest parcel M15, 30 m, 15 Feb. 2001, *A. P. Davis & F. Rakotonasolo 2719* (holotype, TAN; isotypes, BR, K, P, MO, TEF). Figure 1.

Affinis *H. amoeno* sed spinis carentibus, floribus majoribus (corolla 10.5–16.5 cm longa nec 1.5–5 cm longa), antheris et stylo inclusis (non exclusis), ovario et fructu tetralocularibus (non per partem maiorem bilocularibus), pericarpio crasso (0.6–1 cm nec 0.1–0.2 cm), differt.

Tree or small tree, 4–14 m high, DBH 5–14 cm; bark ± smooth, gray to dark brown; branches scaly, gray to brown; branchlets cylindrical, 3.9–6.5 mm diam., smooth (young) or ± smooth to rugose (old), brown to dark brown, ± glabrous; stipules caducous or semi-persistent at the apex of the branches, adnate, ± inrolled and pressed together at the base, deltate to triangular, 1.1–1.4 × 2–2.3 mm, glabrous, apex attenuate to acuminate. Leaves with petiole 0.7–1.7 cm long; leaf blade elliptic to oblong, 3.5–12 × 1.5–4.5 cm, coriaceous, surfaces ± concolorous, base acute to cuneate, margins subrevolute to flat, apex acute to obtuse; abaxial surface glabrous, midrib prominent but becoming flat from base to apex, secondary nerves 5 to 7 pairs, manifest to indistinct, ascending at an angle 45° to 60°, curved near the margin and joining the next (i.e., brochidodromous), tertiary venation indistinct; adaxial surface slightly shiny, glabrous, venation less clearly manifest than the abaxial surface. Inflorescence initiated in a terminal position but overtopped and then appearing axillary in the second or third node from apex, 1(to 2)-flowered, sessile or shortly pedunculate; peduncle 0.5–1 mm long. Flowers 5-merous, sessile or shortly pedicellate, pedicel(s) 0.5–1.5 mm long; bracteoles 2, located at the base of the calyx, adnate from the base to ⅓–½ their length, broadly ovate to ± ovate, 2–2.4 × 1.5–2 mm, internal surface pubescent, external surface glabrous, margins pubescent, apex acute to obtuse; calyx including hypanthium 4.2–5.5 × 3.1–4.6 mm, calyx limb tubular, 4.5–11 × 3.2–4.7 mm, external surface glabrous, internal surface pubescent to puberulous; calyx lobes ovate to deltate, 0.9–1.7 × 1.1–1.7 mm, external surface glabrous, internal surface pubescent, colleters absent, margins glabrous, each apex acuminate to apiculate, 0.4–0.6 mm long; corolla tubular, slightly funnel-shaped, 10.5–16.5 × 0.3–0.5 cm, white to greenish white; corolla throat 3.6–6 mm diam.; corolla tube 9–13.9 × 0.3–0.5 cm, white to greenish white, glabrous, internally with a diffuse ring of hairs at the base, corolla lobes narrowly elliptic to narrowly lanceolate, 2.3–2.8 × 0.4–0.6 cm, white, glabrous; anthers included, sessile, anther sacs linear, 15–18 × 0.7–1.2 mm, supramedifixed ⅓ from the apex, dorsifixed, introrse; disc annular, 0.5–0.8 mm high, glabrous; style included, narrowly cylindrical, 4.8–5.8 cm long, glabrous; stigma ⅓–½ the length of the corolla tube, bifid, lobes very narrowly elliptic to lorate, 8–17.5 × 0.9–1.5 mm, apex acute to obtuse, glabrous; ovary 4-locular, placentation axile, ovoid to spherical, 2–2.7 × 1.5–2 mm; ovules numerous per locule. Fruits ovoid to spherical 2.9–4.6 × 2.6–3.7 cm, smooth, green to yellow (living material), glabrous; fruit wall (i.e., pericarp) 0.6–1 cm thick, crunchy and rather tough (living material) to very hard and almost woody (when dry); calyx limb persistent, 3.5–6 × 3.3–4 cm long; glabrous; seeds sub-lenticular to lenticular-angular, 4.5–5.5 × 3.6–4.4 × 2.2–2.6 mm, white (living material).

Distribution. Restricted to the littoral forest of southeastern Madagascar (Toliara Province, Taolagnaro Prefecture), in the forests of Petriky, Mandena, and St. Luce.

Habitat and ecology. Humid evergreen, littoral forest; on sand or sandy soils (including stabilized

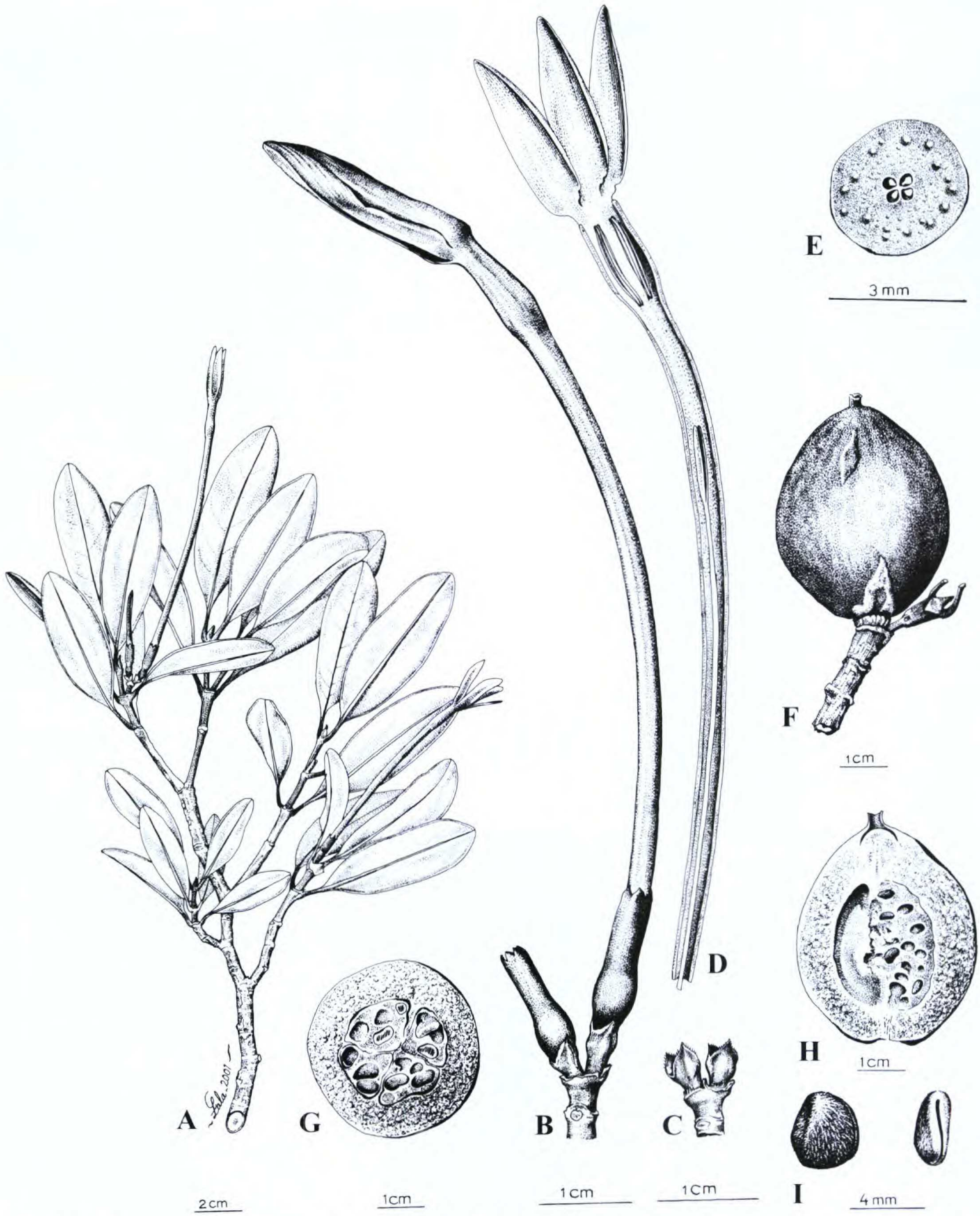

Figure 1. *Hyperacanthus mandenensis* Rakotonasolo & A. P. Davis. —A. Habit: flowering portion cut from branch. —B. Inflorescence (one corolla fallen), with each calyx (incl. hypanthium) subtended by paired bracteoles. —C. Paired bracteoles of inflorescence, calyces (incl. hypanthia) and corollas removed. —D. Corolla dissection, showing included anthers and style. —E. Transverse section through hypanthium, showing 4-locular ovary and vascular bundles. —F. Infructescence, with persistent paired bracteoles at the base of the fruit. —G. Transverse section through fruit, showing 4 locules and thick fruit wall (pericarp). —H. Longitudinal section through fruit, with persistent calyx at apex. —I. Seeds, side and end views. A–I based on *Davis & Rakotonasolo 2719*. Drawn by Roger Lala.

Karimbolian dunes) and possibly restricted to ilmenite-rich sands; sea level to 50 m.

Phenology. Flowering: September to April; fruiting: October to May.

Biology. Insufficiently known but according to Bollen (2003: 45) exclusively dispersed by the collared lemur (*Eulemur fulvus collaris* E. Geoffroy, 1812).

Conservation status. IUCN Red List Category (IUCN, 2001): **Endangered** (EN B1ab (i, ii, iii, iv, v) + 2ab (i, ii, iii, iv, v)). B1—extent of occurrence less than 5000 km² (*H. mandenensis*: 137 km²); a—severely fragmented and known to exist in no more than 5 locations (*H. mandenensis*: 22 collections, 9 geo-reference points representing 4 localities); b (i–v)—continuing decline inferred due to proposed mining and associated activities; B2—area of occupancy estimated to be less than 500 km² (*H. mandenensis*: 96.1665 km² based on seven cells of 3.7 km²).

Hyperacanthus mandenensis is restricted to the littoral forests of Mandena, St. Luce, and Petriky in the Taolagnaro (Fort Dauphin) region of southeastern Madagascar. These three littoral forest areas occur almost exclusively on ilmenite-rich sands, an area that corresponds to a proposed mining site (see ⟨www.riotinto.com⟩). The ilmenite is extracted mainly for titanium dioxide. The methods used to extract these mineral reserves lead to the complete destruction of forest cover. At the present time *H. mandenensis* is near the upper limit of the Endangered (EN) category of the IUCN Red List Categories (2001), particularly by its extent of occurrence (ca. 137 km²; see above). Even a relatively small loss of range (a reduction in the extent of occurrence to less than 100 km²) would result in an conservation assessment of Critically Endangered (CR). The extirpation of Petriky, Mandena, and St. Luce would result in the extinction of this species from the wild. A drastic reduction in the size of these forests, or severe degradation, may also cause this species to become extinct. Like many other Rubiaceae, *Hyperacanthus* rarely occurs in secondary forest.

Records of *Hyperacanthus mandenensis* (as "*Rothmannia mandenensis*") from littoral forests other than those listed above (and see locations for paratypes, below) are erroneous.

Vernacular names. Taolanana, Taholana.

Paratypes. MADAGASCAR. **Toliara Province:** Taolagnaro (Fort Dauphin) Prefecture, Manambaro, Petrika [Petriky], 5 Dec. 2002, *Rakotonasolo et al. 570* (BR, K, MO, P, TAN, TEF); Mandena mine area, 'jardin botanique,' 6 Oct. 1990, *Dumetz 1283* (K, MO, TAN); Mandena, piste SE, 7 Dec. 1989, *Dumetz & McPherson 1145* (K, MO, TAN); Mandena, 17 Apr. 1989, *Dumetz et al. 687* (TAN); Station Forestière de Mandena, 24 Mar. 1989, *Rabevohitra, Dumetz & Gereau 1793* (K, MO, TAN, TEF); Jardin Botanique de Mandena, 25–26 Oct. 1989, *Rabevohitra 2081* (K, MO, TAN, TEF); Mandena, 17–20 Mar. 1997, *Rabevohitra R.3211* (*SF 34943*) (MO, TEF); ca. 10 km NNE of Fort Dauphin (Taolagnaro), Mandena, 27 May 1991, *Zarucchi et al. 7513* (K, MO, TAN); Mandena, 21 Dec. 1952, *sine coll. 231-R-16* (TEF); Fort Dauphin, [Mandena], Sep. 1890, *Scott Elliot 3036* (K); Station Forestière de Mandena, 9 Dec. 1972, *Jacquemin 1152* (K, P); Forêt de Mandena, 16 Mar. 1985, *Dorr et al. 4002* (K, MO); St. Luce, Forêt de Marokoky, 25 Apr. 1989, *Rabevohitra, Dumetz & Gereau 1914* (K, MO, TAN, TEF); N of Fort Dauphin (Taolagnaro), near St. Luce (Manafiafy), 21 Oct. 1989, *McPherson et al. 14199* (MO, TAN, TEF); N of Fort Dauphin (Taolagnaro), St. Luce region (Manafiafy), 19 Oct. 1989, *McPherson et al. 14165* (MO, TAN); N of town (Fort Dauphin) near village of St. Luce (Manafiafy), 18 Jan. 1990, *McPherson et al. 14832* (MO, TAN); N de Manafiafy, 12 Nov. 1990, *Rabevohitra 2436* (*SF 33665*) (MO, TAN, TEF); Mantalaky, Manafiafy (St. Luce), 30 Nov. 2002, *Rakotonasolo et al. 542* (BR, K, MO, P, TAN, TEF).

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Literature Cited

Bollen, A. 2003. Fruit-Frugivore Interactions in a Malagasy Littoral Forest: A Community-Wide Approach to Seed Dispersal. Ph.D. Thesis, University of Antwerp.

Bridson, D. M. & E. Robbrecht. 1985. Validation of the African genus *Hyperacanthus* E. Mey. (Rubiaceae tribe Gardenieae). Kew Bull. 40: 273–286.

Davis, A. P. & D. M. Bridson. 2003. Introduction to the Rubiaceae. Pp. 431–434 *in* S. M. Goodman & J. P. Benstead (editors), The Natural History of Madagascar. Univ. Chicago Press, Chicago & London.

——— & F. Rakotonasolo. 2003. *Gardenia* and related genera (tribe Gardenieae subtribe Gardeniinae). Pp. 441–442 *in* S. M. Goodman & J. P. Benstead (editors), The Natural History of Madagascar. Univ. Chicago Press, Chicago & London.

IUCN. 2001. IUCN Red List Categories: Vers. 3.1. Pre-

pared by the IUCN Species Survival Commission. Gland, Switzerland, and Cambridge, United Kingdom.

Rakotonasolo, F. & A. P. Davis. 2001. *Hyperacanthus ambovombensis* (Rubiaceae): A new species and new generic record for Madagascar. Kew Bull. 56: 945–953.

——— & ———. 2002. Notes on the genus *Hyperacanthus* (Rubiaceae) including the description of a new species from Madagascar: *H. grevei*. Kew Bull. 57: 955–962.

Willis, F., J. Moat & A. Paton. 2003. Defining a role for herbarium data in Red List assessments: A case study of *Plectranthus* from eastern and southern tropical Africa. Biodiv. Conserv. 12: 1537–1552.